Accelerator Systems Division Highlights for the Week Ending April 4, 2003

ASD/LANL: Warm Linac

HIGH-POWER RF (WBS 1.4.1.1)
Accomplishments This Week: (1) Two CPI 550-kW, 805-MHz klystrons completed their site acceptance tests this week. (2) The second superconducting transmitter is scheduled to complete its factory acceptance test this week.
Concerns & Actions: (1) Thales 550-kW, 805-MHz klystron #4 failed its tests in preparation for a factory acceptance test that was scheduled for next week. The failure was reported to be due to a water leak (no more specifics provided yet). The factory acceptance test has been postponed. (2) The 5-MW RF system continues to be our biggest concern. Testing remains suspended pending repairs of broken circulator, loads, and sliding short. The circulator vendor (AFT) is still planning to visit this month. The klystron vendor (Thales) is still trying to resolve the output transition arcing problem.

HIGH-VOLTAGE POWER CONDITIONING (WBS 1.4.1.2)
Accomplishments: (1) The prototype HVCM ran flawlessly all week in support of klystron testing. The klystrons being tested, however, were the 550-kW, 805-MHz units, so the required power output by the converter modulator was low. (2) The production HVCM continues on-site modifications and repairs prior to installation at LANL, which should take place next week.
Concerns & Actions: (1) The primary repair required on the production HVCM delivered to LANL was to one of the three high-voltage step-up transformers. As in the units that had been delivered to ORNL, this transformer had an incorrect turns ratio that had to be fixed. In addition, some minor modifications are being done to the IGBT switch plate assemblies. (2) QA personnel from LANL and ORNL are visiting Dynapower next week to address quality issues with the production HVCMs.

LOW-LEVEL RF CONTROL SYSTEM (WBS 1.4.1.3)
Accomplishments: (1) Following a minor change to the prototype DFE board, we were able to successfully program the onboard FPGA chip. The board is currently undergoing complete unit testing to measure the noise characteristics of the components as well as verifying its functionality. Craig Swanson of ORNL was at LANL this week to assist with board testing. (2) The RFO board was received on March 27 as expected. It is fully assembled, including long-lead components that we received this week. (3) We received the printed circuit boards for the DFE test unit, and the assembled units are expected to be completed late today (Friday).
Concerns & Actions: (1) Testing of the RFO board has been delayed because of John Power's involvement with the BPM electronics (see below). However, it is not on the critical path so there is no schedule impact. (2) We are still on course to have the final LLRF system ready for testing with the DTL at ORNL in mid June.

DRIFT-TUBE LINAC (WBS 1.4.2)
Accomplishments: (1) Dummy Tank-3 BPM drift tubes 3-2 and 3-8 were shipped on Thursday, to arrive at ORNL on Friday, April 4. (2) Slug tuners #6 & #7 for Tank 3 are being machined to length and will ship no later than next Monday, April 7. (3) The Iris/RLWG for Tank 1 is projected to ship to ORNL on April 10. (4) Seven salvaged Tank-1 drift tubes (empties) are en route to LANL for final processing; these are projected to ship to ORNL on April 8 or 9. (5) Twelve of the Tank-1 rebuilt drift tube have had both faces profiled and six have been leak checked. We have begun stem welding and project we will ship the first batch of eight on April 14, with similarly sized batches being dispatched every two or three days after that. (6) Thirty-five Tank-1 top hats are in the final stages of machining. (7) The Iris/RLWG for Tanks 4 and 5 are scheduled to go out for the second plating operation next week. (8) Diverters adequate for the first two batches of Tank-4 drift tubes were brazed. (9) The Tank-4 stand is scheduled to start machining at CMI next week with a projected ship date to ORNL of April 18.
Concerns & Actions: (1) The DTL critical path item from last week (the last two Tank-3 drift tubes) were shipped in time to support the latest DTL commissioning plan. (2) Jim Billen will travel to ORNL this weekend to support tuning of Tank 3. (3) A new welding fixture for post couplers has been fabricated and will be tested in the next week or two. (40 Salvage of the Tank-1 upstream end-wall tuning ring was approved and documented. (5) Weld qualification was completed at Hanford, and we are ready to proceed into production of Tank-4 DT water-channel welds. (6) The procurement package for a drift-tube prototype for qualification of a second machining vendor is at the vendor. (7) The e-beam weld development qualification for EDM and BPM drift tubes was successful, and arrangements have been made to braze stems at Alpha Braze.

COUPLED-CAVITY LINAC (WBS 1.4.4)
Accomplishment: (1) ACCEL has completed the stack braze and leak checking on six CCL segments. LANL staff will visit next week to start final tuning of these segments, as well as other activities listed in last week's report.
Concerns & Actions: (1) The physics team continued working with ACCEL staff to tune CCL Segments 3, 4, 5, 6, and 7. The additional experience and tuning data have led to refinements in estimates of the effects mentioned previously of missing wire alloy filling the grooves.
PHYSICS, DIAGNOSTICS, CHOPPER (WBS 1.4.5)
Accomplishment: (1) We used a 3-D model of a DTL cell to assess the power dissipated on parts of the "top hat" exposed to RF fields. (Copper plating on some of these parts has been problematic, and the question arose as to whether the copper plating is needed when making more of the top hats.) The power density on the small amount of stainless steel that would be exposed near the multi-lam RF seal is about 0.1 W/cm^ 2, which is low enough that copper plating is unnecessary. (2) We received the new boards for the BPM electronics from the vendor and have nearly completed assembly of the three units needed for the Diagnostics Plate. We will ship these units to ORNL next week, followed by a visit by John Power and Matt Stettler to check them out in place.

ASD/JLAB: Cold Linac

Measurements on Cavity 1 of module M-1 have demonstrated acceptable gradient performance (see chart). Testing of the module has been interrupted, and the cryomodule warmed up, to investigate and correct problems with the tuners on cavities 2 and 3. While this is being done, a minor leak from the low-pressure helium process piping into the insulation vacuum will be investigated. Assembly of module M-2 was halted until the nature of the tuner problem on M-1 is understood. The second module had reached the point in the assembly process where further work would have made the tuners more difficult to reach and repair, if that is indicated by the results of the M-1 investigation. All effort has switched to assembly of the M-3 module.

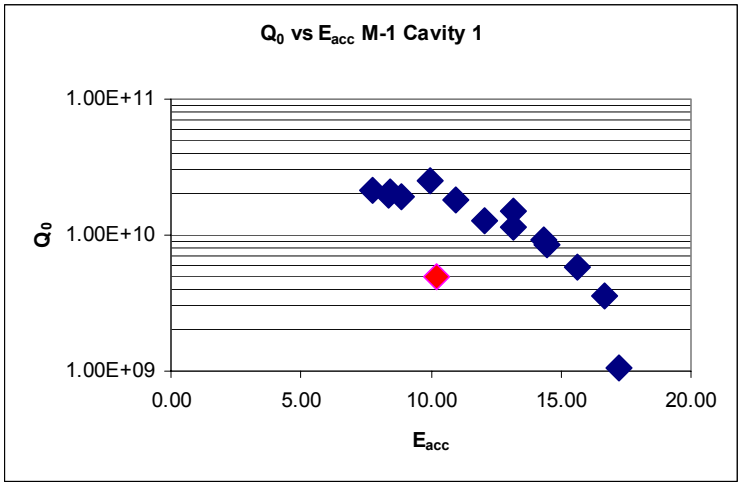


Figure 1. Module M-1, Cavity #1

Leak tests have shown that the minor sealing surface damage observed on cavities MB-14 and –16 (one flange each) is not sufficient to prevent leak-tight seals. Assembly of the M-4 string will be done next week.

The helium vessel has been welded on the first production high-β cavity.

Repairs to the leaky purifier have been completed, and the unit will be shipped to SNS next week, along with a crate of valves and the purifier maintenance frame.

The cold box lower end bell copper shield of the 2 K Cold Box has been installed (see photo). Internal piping fit up is complete with the exception of the first stage suction header and LN2 return lines. Installation of the cold box electrical feed-throughs has started.

ASD/BNL: Ring

Visit from ASD (Hechler and Hunter) to BNL for installation discussion.

Chicane magnet #1 contract is awarded to Alpha Magnetics.

Bids were received for the external shielding for the two HEBT collimators. Some scope reduction change is done, and requested best and final bid.

Ring half-cells: Shipped #5 and work continues on half-cells # 6 and 7.

21CO26: magnetic measurements are complete, and result is attached.

HEBT quads: twelve more quads have been shipped this week.

RF Tune PS: Passed the test with flying color, and the remaining production units (3) will be shipped directly to SNS/OR.

Set up for the interference between the ring quadrupole, corrector dipole/skew quad and corrector sextupole measurement is under way. A calculation shows little effect on the multipole effect.

Controls

In this weeks timing news...

- The site timing master IOC was upgraded to generate a 16-frame RTDL and several new events, including a "Source Test Stand" trigger gate that will run out of phase with the regular ion source trigger gate.
- The HPRF timing database was modified to get the RF gate width over the RTDL instead of via channel access.
- The MEBT LLRF timing database was modified to get the RF gate width over the RTDL instead of via channel access.
- Timing hardware was installed and checked out for the new dtl-hprf-ioc3 HPRF IOC.
- The startup checkout procedure for the timing master IOC was executed (and it passed).
- Work on Timing System documentation continued, in preparation for the departure of the guru

- A farewell pizza party was held for the guru. See pictures below:

MEBT quad power supply controls were checked out in collaboration with the Electrical Group. Test results were good after problems (faulty terminations) with the optical fiber connecting the Group 3 CNA modules and with the DB-25 connector mountings on the bathtub chassis in the new rack were found and corrected. Wiring diagrams are being corrected to "as built."

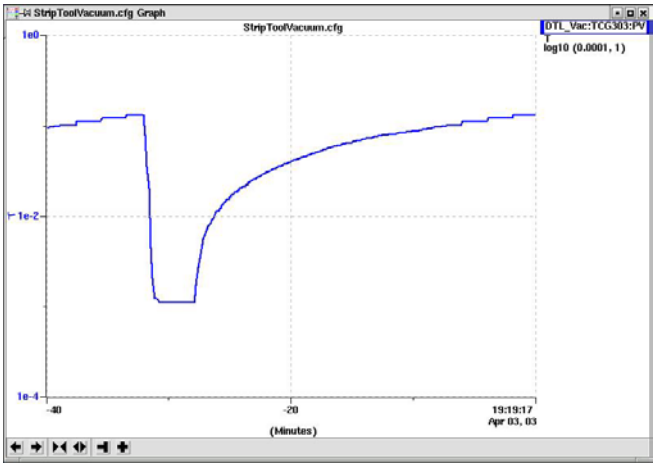
Arrangements have been made for installation of cable and cable tray for the Ion Source Hot Spare. Cables are being unpacked and labeled.

Work continued on operator screens for magnet power supplies, and on getting the power supply control system software working in the test stands in 701SCA, RATS Bldg. and in the CCL rack in the Klystron Gallery.

Preparations for running DTL Tanks 1 and 3 and the D-Plate continued. All system work was completed network connected, memories flashed. Tasks related to "lessons learned" from the Front End commissioning run were assigned.

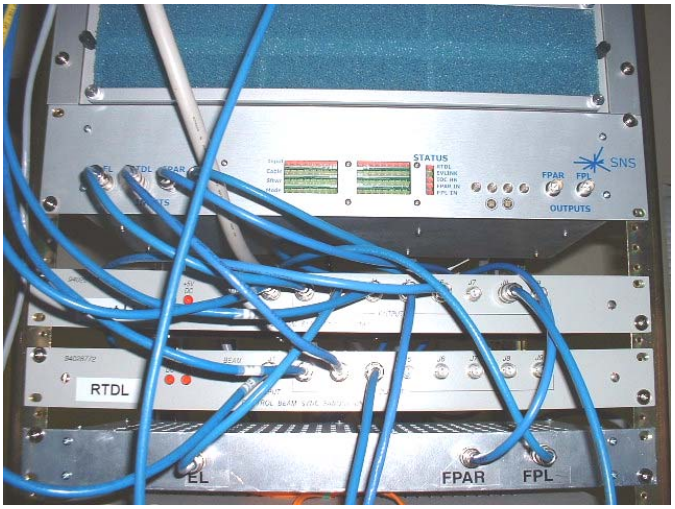
A design review of the HEBT SB ring controls system block diagram was held this week. A specification for the HEBT SB Controls rack fabrication was drafted and issued for review. Functional Specification Documents were drafted for Alarms and IOC Operations.

Hytec serial hardware and software has been integrated with DTL vacuum controls. This enables the control system remote gauge pressure readings. The illustration below shows DTL-tank-3 vacuum leak analysis using an EPICS tool. During this integration work, many wiring errors have been found. Much time of this week dedicated to wiring/functional test.



The Controls Team hosted a course this week in use of EDM – the display manager being used for all control room EPICS displays. This course was well attended – perhaps too well attended.

In preparation for the first use of Beam Loss Monitors (BLMs) in the upcoming DTL run, a Machine Protection System (MPS) was installed and configured at BNL. This system will be used to verify the BLM to MPS interface. It will also be used to verify the MPS interface with vacuum and beam dump equipment used in later runs.

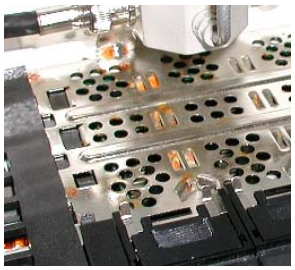


The installation of the Personal Protection System (PPS) equipment required for DTL 3 conditioning is 80% complete. The control panel is installed and powered and the PLC program is ready for testing. Field cabling has been pulled and partially terminated. The east access PPS gate is installed but the PPS devices are not installed. The radiation detectors (ORNL monitrons) and the PPS gate devices are on hand and ready for installation.

The installation drawings and cable databases for the installation of field devices are 90% complete. A final field walkdown of the CHL is scheduled for Monday, April 7 to finalize the drawing prior to CFC. CHL cable installation should start in mid-April.

The Main 4.5 K Cold Box PLC rack was installed on the platform above the cold box in the Central Helium Liquefier building. All ICS racks for control and monitoring of the CHL process equipment have now been installed.

Before the warm compressors were moved from the RATS facility, the PLC modules were removed and stored in a protected location. This has proved to be a good decision. At some point while the skids were at the site, water leaked into the skid 4 cabinet and rusted the PLC chassis. (See photos below.) The PLC chassis and power supply will be replaced prior to any testing activities.

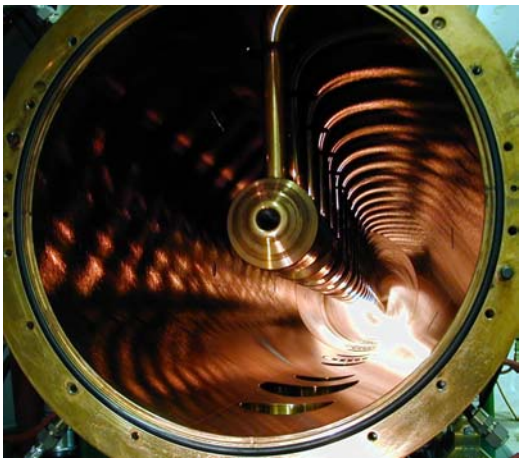


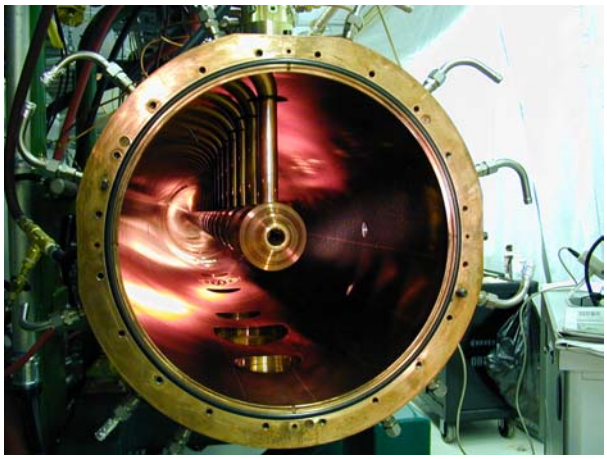
Installation

Craft Snapshot 4/2/03

ASD craft workers	67.0
Foremen, ES&H, etc	9.0
Less WBS 1.9 controls	4.0
Less absent	5.0
TOTAL	69.0

The last two (2) DTL #3 drift tubes were received from LANL on 04APR03. They were fiducialized and installed Friday. Post couplers and tuners were installed on 05APR03. The bead pull hardware and electronics were set up on Sunday 05APR03.





These important steps represent the completion of IPS Milestone PEP 2-09 Start Linac Installation (DTL).

The High Beta Wave Guide shipment expected 20MAR03 was received 03APR03.

Planning for Cryomodule Installation was reviewed. This activity is planned to begin in JUL03 with the installation of the first three (3) Medium Beta Cryomodules.

DTL #1/D-Plate Installation is proceeding with good progress on completing cabling terminations and integrated testing.

Cable tray installation in the HEBT Service Building was started.

The trip to BNL by ASD personnel last week yield new information on Component Deliveries.

Accelerator Physics

Operations Group

ARR Preparation

Conduct of Operations – Complete- on the web, out for review.
Revising and approving OPM sections needed for the ARR and listed in the COO
Writing the Accelerator Safety Envelope (ASE) for DTL Tank1 Commissioning.
Updating Emergency Procedures
Migration of Review documentation data to ProjectWise

We are working on integrating the Group-Sub-Group, Sub-Sub-Group structures across the Division software systems including ETS, E-Log, Call-Down, CMMS, and Beam Accounting.

ASD Maintenance Plan

DataStream 7i installation contractor visited Monday- Wednesday. Operations and Project Office MIS Personnel worked on data conversion with the contractor.

Training

Revising training modules and training operators for DTL Tank 1 Commissioning
All operators are required to take the RGD Custodian training

Three Operations Personnel participated in the 2-day EDM Training so that operators can create EPICS screens

We worked with BNL on updating the ASD Spares list.

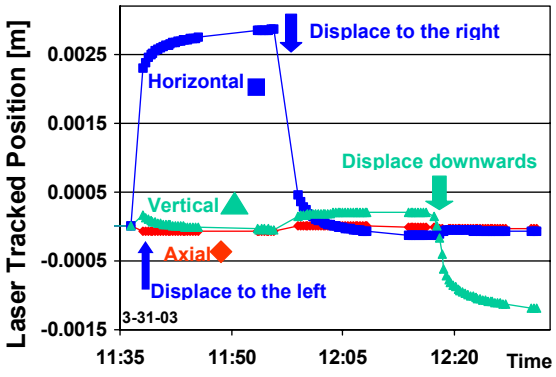
We continue to do CLO laboratory space planning for ASD.

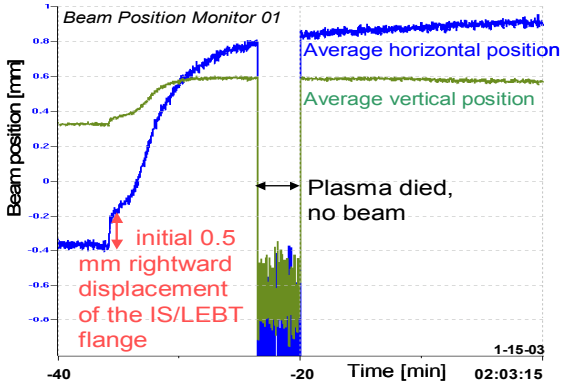
Ion Source Group

Installation of the Hot Spare Stand continues in the Front End Building.

We are preparing for the reinstallation of the LEBT.

On Monday Survey and Alignment setup the laser tracker to survey the LEBT area. They found the RFQ entrance flange to be roughly 0.1 mm below to the position measured in early March, after it was realigned. This confirms that the RFQ is now properly aligned. Then the laser was setup to track the position of a fiducial on the LEBT flange. After tracking for a few minutes, the LEBT flange was moved roughly 2 mm to the left, using the installed LEBT positioning device. After the roughly 1 minute long, intentional move, the LEBT flange kept drifting more than 0.5 mm over the next 20 minutes. A similar behavior was observed when the flange was returned to roughly its original position. A subsequent intentional downward move induced an even stronger subsequent creep.
The 3 coordinates of all individual position measurements are in the left figure shown below. They show the position creep to be a very smooth movement. The creep appears to be coming from the positioning system that slowly relaxes after it had been strained during operation. The time constant, however, is surprisingly long. The figure also shows the horizontal and vertical motions to be slightly coupled (5-10%).
This finding can explain the BPM01 measured beam position that drifted a long time after the LEBT flange was displaced during front end commissioning on January 15, 2003. This characteristic of the positioning devices significantly complicates alignment efforts. Therefore, in collaboration with the Mechanical Engineering group, we have initiated plans for replacing the positioning devices with a simpler system with a significant smaller potential for storing energy.





Survey and Alignment Group

Mechanical Group

Magnet Task

HPRF

Installed IP addresses in HPRF DTL3 transmitter PLC, verified Ethernet connection to EPICS.

E2V added a 5 kW 2nd cavity load on their 402 MHz klystrons to meet bandwidth specs. We located this load on cooling cart using the spare circuit @ 5 gpm. This permits monitoring flow but not temperature. The spare temperature circuits are presently used for DTL window monitoring.

A "gate fault" indicator prevented the DTL3 transmitter to come up to "Ready for HV". The solid-state amplifier was replaced to correct this condition. The amplifier will be returned under warranty.

Two lead shields arrived from E2V for the 402 klystrons. They were sent to the ORNL lead shop to be modified to permit manual installation without a crane.

Six 805 MHz 550 kW klystrons are being stored in the RFTF. Numerous ancillary components have also arrived. Large shelves have been constructed to store components. The klystrons have been extracted from their shipping containers and placed vertically to save space. The congestion will be alleviated when the superconducting transmitter oil tanks arrive and the klystrons, magnets and tanks can be stored in the klystron gallery.

LLRF

ORNL

Preparation for DTL1&3 testing and commissioning is ongoing. The primary focus this week was preparation for high power RF testing of the DTL3 klystron.

Installation of the reference system continued with emphasis on completing the cabling needed for DTL1&3.

Craig Swanson spent the week at Los Alamos working with the LANL team on the checkout of the prototype DFE and the preparation of the VHDL code targeted for the DFE.

Hengjie Ma and Mark Champion visited JLab and carried out tests of the RF control system with the first production medium-beta cryomodule. Two evening shifts and two day shifts were supported by JLab staff. We collected open- and closed-loop system characterization data at gradients from 2 to 16 MV/m; we studied the interaction between the piezo tuner and the RF control system; and we demonstrated pulsed measurement of Qo under fixed-frequency operation.

LANL

Hardware Platform: Work continues on producing the “Rev 0” of the new hardware platform for the LLRF system. We are still on course to have a system ready for testing with the DTL at ORNL in mid June. The hardware platform consists of the following boards:

Analog Front End (AFE): This board has passed all the unit tests and is ready for integration with other hardware components.

Digital Front End (DFE): Following a minor change to the prototype board we have been able to successfully program the onboard FPGA chip. The board is currently undergoing complete unit testing to measure the noise characteristics of the components as well as verifying its functionality. The tests are expected to be completed by April 20. Craig Swanson of ORNL was at LANL this week to assist with board testing.

RF Output (RFO): The board was received on 3/27/03 as expected. It is fully assembled including long-lead components, which we received this week. Testing has been delayed (not on critical path) due to engineers’ involvement with SNS diagnostics work.

Motherboard: The design has been released to fabrication and components have been ordered (60% in house). Incorporating the reviewer comments delayed the final date by about one week, and the completed prototypes are expected on April 18.

DFE Test Board: This is a simpler version of the DFE to help with testing the AFE and the RFO boards. We have received the printed circuit boards and the assembled units are expected late today.

HPM Board: Work continues on the final REV of this board. It is expected to be released to fabrication and assembly the week of April 21. Paul Stein of BNL (formerly of LANL), who designed the original firmware, has been drafted to provide the modifications to this REV as well.

Testing: Work continues on developing test plans: have almost completed RFO and the motherboard. We are also developing a test matrix to cover every VHDL module.

LBNL

Larry completed the implementation of the Xilinx firmware compiling software on our Linux systems, so that we can now compile code from anywhere with a remote login. We can also install this on laptops. This system is based upon the software distributed by Xilinx and used at JLAB during the tests last month.
We are 80% done fabricating the DTL1 chassis. This should be completed early next week so that the testing can begin later next week. We are on track to ship the unit on or before April 18 as promised.

The credit card procurement system changes at LBNL have definitely slowed down our purchasing speed. We had to change the current path to speed up the procurement of additional nanoEngines and of the RLC filters, which are the long lead items for the fabrication of the remaining chassis. These orders are now at the desk of the buyer, but not placed yet.

We returned a nanoEngine to the manufacturer for repairs. With this CPU gone, we now don't have a spare system, but are hopeful that the new order and the repaired unit will come in soon.

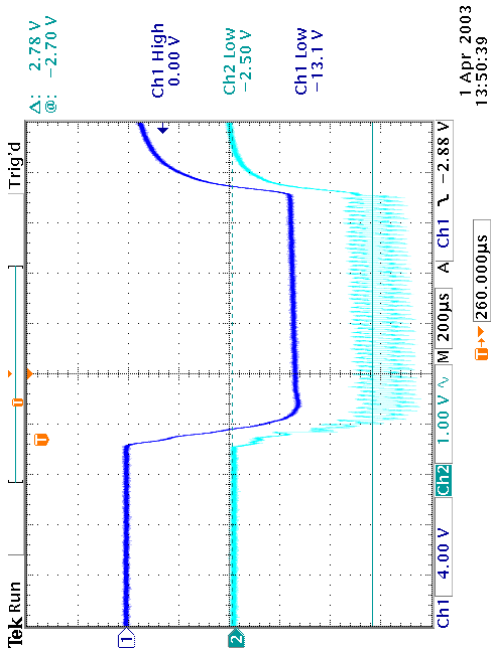
Larry tested two digital boards of the new batch. They both passed the tests although a glitch is being investigated.

A glitch was found in the digital systems and is now under study. It appears that the 40 MHz clock bounces at times generating a false trigger in between the normal pulses. This seems to appear when a full set of signals are all pulled on or off at the same time in a certain region of the register map. Interestingly, changing the nanoEngine made the problem disappear! Larry is working on this to understand what is happening and looking back in our logged data to determine if this was happening in previous systems as well.

We received the visit of Alan Jones of the controls group. Working with Larry, Alan learned and familiarized himself with the firmware used in the LEBT chopper pattern generator system, which is implemented in the same hardware as the MEBT LLRF. After this trip, Alan should own the system and be able to support the MPS requests based upon this hardware.

Electrical Systems Group

Performed successful crowbar testing on ME2 HVCM at voltages up to 90 kV multiple times. Operated ME2 up to 130 kV, 30 Hz, 1 ms pulse width for ~2 hours (see attachment). Lower ripple and improved overshoot compared to ME1 lends further evidence that ME1 failed due to problems with imbalanced turns ratios and polarities on the secondaries. Readied ME2 for klystron operation. Continued installation of RFTF HVCM, including installation into tank, reassembly of IGBT switch plate assemblies, installation of SCR retrofit parts, etc. Shipment of ME1 replacement transformers has been delayed; new delivery date is April 7th at ORNL. Completed a complete checkout procedure for HVCM units.



To view this picture with the correct orientation, please rotate your monitor by 90 degrees.

DTL3 thermocouple cabling finished but not terminated yet

DTL1 and DTL2 instrumentation trunk and rack terminations completed.

HEBT SB installation of cable trays has started on Thursday in spite of other contractors still in the building.

HEBT tunnel contractor preparatory walk through prior BOD completed.

Installation started on DTL1 and DTL2 dipole corrector power supplies. The DTL2 dipole steering supplies will be used for the D-plate quadrupole and corrector magnets.

Re-installation of the front-end quadrupole magnet power supplies is complete. Testing and check out started.

Cryogenics Group

CHL: The charcoal absorber is filled with charcoal, however the weather hampered installation of the top filter. A nitrogen purge was established and the vessel was wrapped with plastic to keep out the rain. Installation of the top filter will continue when weather permits.

Tunnel: The 10" line of the upstream return modules has been cold shocked and will be leak checked this week. A second installation crew will start working in the tunnel next week.

RATS: The return expansion can inner piping was installed into the outer vacuum vessel. Photo is attached. Completion of the expansion can is expected next week.

Beam Diagnostics

BNL Beam Diagnostics Progress report:

1.5.7.1 BPM: Completed SNS RF BPM schematic incorporating recommendations made during the design review. Revised calculations of noise due to the new MUX and redesigned the circuitry to reduce noise. Delivered 10 more 12cm HEBT BPMs to vacuum group. Finished inspecting parts for the additional six 30cm BPMs. Parts are being cleaned.

1.5.7.3 BLM: Construction continues on the AFE test stand. Discussions continue with Controls on IOC interface with the AFE test stand. A variety of parts have been ordered for the AFE chassis and the MPS comparator module. AFE back plane work continues. Detailed radiation pattern measurements were taken at our Cesium-137 source to map the field so that we can determine the position that the new ION detector must be located to properly interpret the data. Sole source paperwork has been submitted for the ISEG HV supply. Effort on the movable BLM stand design is underway.

1.5.7.4 BCM: A new PC has been made ready and loaded with BCM software. It has been outfitted with a LANL PCI card and a BCM AFE board, and is presently running for software development efforts. The 11 HEBT, Ring and RTBT FCTs have been characterized for transfer function and droop time constant and are ready for installation in vacuum chamber shrouds. Four calibrators for delivery April 15th are under construction. Work continues on the support design and the production drawings for the HEBT BCMs.

1.5.7.6 Carbon Wire Scanner: Finished welding 6 HEBT WS beam box assemblies. Six more assemblies are presently in welding.

1.5.7.7 BIG: An additional vendor was identified for the pulser unit (Polarity Inc. of California). A quote was received for $515K, however, there was a misunderstanding and they will provide another quote. They suggested a preliminary feasibility study be performed first at a cost of $25K. Looked into committee's suggestion to check on tube based switches. This did not pan-out due to costs and placing tubes in the Ring.

ORNL Beam Diagnostics Progress report:

D-Plate: Ernest and company tested the entire D-plate emittance electronics via EPICS. Minor problems with the limit switches were encountered. Anthony Webster is addressing that and all issues with limit switches and collision avoidance system. Ernest is also calibrating the pre-amps/digitizers via the emittance program. EE group is taking care of the wiring of the vacuum and RCCS. EE group has also decided to use the DTL power supplies for the D-

plate quad and steering magnets. Their reasoning is the CCL power supplies are late and the alternative will be used. The Controls and Diagnostic groups will readjust to the new decision.

One of the NADs received from LANL is damaged in transportation. We will resolve that in the coming week. Anti-Chopper D-Box: The ORNL designed actuator is in place the prototype is shown below has better than expected resolution. Tom Roseberry (Mechanical group, design engineer) has discovered the Ultra Motion stepping motor is not performing per specifications. The week was spent in identifying the problem with vacuum loaded prototype actuator. Jim Pogge has a couple of solutions. One is the adaptation of the modular planetary gear will reduce the required torque. The other is to adapt an Applied Motion stepper motor driver. Matthew will try the second as we are waiting to receive the planetary gear module. We are still on schedule to complete this project.

Figure 2) ORNL designed actuator under test.

Figure 3) Diagnostic group NAD controlling the D-box actuator. The Alignment group is measuring the reproducibility of the positions as the actuator moves multiple times.

Software: We are in the process of adapting the laser wire data acquisition for the ion source group. Wim is ordering 8 NADs for the D-box. He is also preparing for the visit of the LANL experts.

Reference Oscillator Box: Craig Deibele has purchased one solution from EMF that meets the diagnostic groups requirement. This system even meets the +/- .1 (.7 picosecond) degree jitter specifications for the master oscillator. In parallel, Jim Pogge has been developing an in-house version of the oscillator box, which will replace the Roscoe boxes. The following two pictures show the board and the initial results without the optimum VCO and the crystal.

Even in prototype form, Jim's box at 402.5 MHz provides a phase jitter of about 1.3 ps, an order of magnitude better than the Roscoe box. Development of this technology allows us to address the low-jitter clock requirements in several other diagnostic systems.

Figure 4) Diagnostic reference oscillator with 405.5, 355, 40,10 and 2.5 MHz frequencies, programmable by an onboard microprocessor and an RS232 communication line is shown.

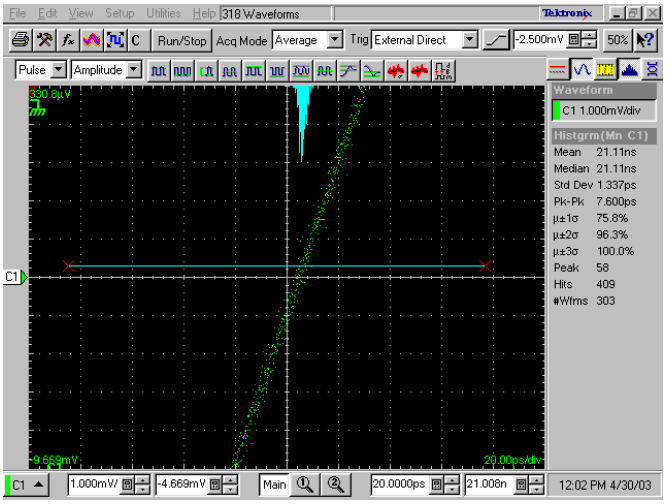


Figure 4) Jitter measurement performed on the prototype circuit that is shown in figure 3. Measured RMS jitter is 1.337 ps.